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The effect of planting scheme and fertilizer rates on the quality of sugar beet

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Sugar beet is a crop of huge national economic importance. The beetroot plant shows great sensitivity to the abiotic factors especially to fertility of the soil. The lack of nutrients in the soil where this plant is grown weakens its normal development and significantly reduces its yield. Therefore, the present research work was planned to assess the impact of planting schemes and mineral fertilizer norms on the quality production of sugar beet. Research works were carried out in 2021-2022 with Caucasian variety of sugar beet on irrigated gray-brown soils. The field experiments were laid out under different plnating schemes and fertilizer application rates. In case of 50x20 cm planting scheme without fertilizer (control); dry matter 21.4%, sugar 15.6%, protein 5.38%, fat 0.61%, cellulose 5.69%, ash 4, 46% and nitrate nitrogen 147.5 mg/kg in wet mass, respectively were recorded in background ($P_{120}K_{90}$) variant; 15.9%; 5.85%; 0.65%; 5.77%; 4.53% and 163.8 mg/kg.The quality indicators of sugar beet, as well as root and fruit crops, increased significantly compared to the control and background ($P_{120}K_{90}$) variants in the increased rates of nitrogen fertilizer along with the background. The highest quality indicators were observed in the background+N_{90} variant, respectively 24.9%; 17.9%; 6.21%; 0.76%; 6.05%; 4.71% and 183.0 mg/kg. In the 50x20 cm planting scheme, which has more food space, the quality indicators were higher in each of the studied options than in the 50x10 cm and 50x15 cm planting schemes, depending on the mineral fertilizer norms. 0.8-3.5% dry matter, 0.3-2.3% sugar, 0.47-0.83% protein, 0.04-0.15% fat, cellulose 0.08-0.36%, ash by 0.07-0.25% and nitrate nitrogen increased by 16.3-45.7 mg/kg in wet weight. The amount of nitrates in the root fruits of sugar beet was much less than the permissible limit (250 mg/kg in wet weight). It is concluded that the highest indicators were obtained in the background+N_{90} and 50x20 cm planting scheme.
Keywords: Sugar beet, environmental factors, planting scheme, mineral fertilizer, quality indicators.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is worldwide known as the 2nd highly vital sugar yield crop afterward sugarcane, hence recognized a significant industrial crop. Owing to short crop duration and augmented sugar recovery, it is favored to grow as compared to sugarcane. The area under sugar beet cultivation is increaseing yearly basis throughout the world (Abou-Elwafa *et al*., 2020) as well as in Pakistan. Nevertheless, sugarcane is a crop of extend growth period which demandsa reasonable cost of production. Hence, not acceptable by small growers and mediun income farmers and move towards substitute crops. Sugar beet possess a greater sucrose content (14-20%) compared to sugarcane (10-12%) (Mekdad *et al*., 2020). Its water and fertilizer demand is ~30-40% less than sugarcane and it can be grown under various climatic conditions (Varga *et al*., 2022).

The national economic importance of sugar beet is very great, and therefore this plant is included among the main technical crops in most countries (Garcia-Velásquez *et al*., 2023). In our republic, after the most important technical crops such as cotton and tobacco, special attention has been paid to the development of this crop in recent years. Sugar beet is primarily the raw material for buying sugar, which is considered one of the most valuable food products. 40% of the world's sugar production comes from sugar beet. Depending on the variety and hybrid, 16-20% sugar can be collected on average in the root fruits of sugar beet under favorable conditions. It is possible to get 12-15% sugar extract from it after factory processing. By-products obtained from sugar beet processing (leaves, seeds, patka) are very important in animal husbandry.

The importance of sugar beet in the national economy is very great, and therefore this plant is included among the main

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technical crops in most countries (Agamy, 2013). Sugar beet is primarily raw material for buying sugar (Amin *et al*.,2013). By-products from sugar beet processing are very important in animal husbandry (A'ali *et al*., 2017).

The intensity of sugar beet development, the productivity limit depends on many environmental factors (Enan *et al*., 2016). Key factors include temperature threshold, moisture, nutrients and light (Abbas *et al*., 2022). A warm climate is favorable for plant growth and sugar accumulation. (Qotob *et al*., 2019). The high temperature is enough for the intense growth of the leaves, the enlargement of the root and the accumulation of sugar in it (Agamy, 2013). The attitude of sugar beet to temperature depends on the age of the plant and soil and climate conditions.Sugar beet productivity also depends on the amount of atmospheric precipitation during the growing season. Sugar beet uses more water per unit area than most cereal crops (Jaskulska *et al*., 2023).

A lack of moisture in any period of plant development reduces the growth rate of leaves and roots by disrupting physiological processes.

Sowing rate of sugar beet is the main factor determining the production technology of the plant (Tucher *et al*., 2018). Organic and mineral fertilizers are powerful means of increasing sugar beet yield and sugar content (Elshamy, 2016). Compared to other plants, beet plants have a number of characteristics of nutrient uptake (Mekdad *et al*., 2020).

The fertilizing system should take into account the types, rates and forms of mineral fertilizers, the types and rates of organic and bacterial fertilizers, their application periods and methods (Kandil *et al*., 2004). Giving mineral fertilizers to plants accelerates the synthesis of enzymes, improves the plant's use of water, solar energy and microelements, the exchange of nutrients, increases its immunity, resistance to diseases and pests, and ultimately increases the yield and quality of sugar beet (Barone *et al*., 2018).

Nitrogen has a special role among the bulk mineral nutrients used by sugar beet (Hellal *et al*., 2013). Despite the fact that sugar beet shows a need for nitrogen during the entire vegetation period, the lack of nitrogen in the first half of the vegetation period, that is, when the assimilation surface is intensively increasing, seriously disrupts the coloring and development of the plant. (Pradhan *et al*., 2010) Nitrogen deficiency primarily weakens plant growth. The role of phosphorus in the formation of the sugar beet product is great (Ahmed *et al*., 2023) Phosphorus improves the growth of leaves and creates favorable conditions for the roots to reach deeper layers of the soil (Kheir *et al*., 2019). When sugar beet is supplied with phosphorus as required, it is resistant to drought and, at the same time, it is resistant to fungal diseases both during the growing season and during storage of the crop, and the role of phosphorus is also important in the accumulation of sugar in the root fruit (Islamgulov *et al*., 2019). Application of 3% N urea solution to sugar beet plants and fertigation by 75% recommended dose of urea was noted increased the quality of sugar beet produce. Application of magnetic water also augmented the yield and quality of sugar beet produce. Moreover, aerial application of urea is better as compared to soil application and the augmented urea application rates badly affected the yield quality of sugar beet (Faiyad and Hozayn, 2020).

Potassium increases the resistance of the plant to diseases, significantly improves the quality of the harvested product (Gajić *et al*., 2019) When there is a lack of potassium in the soil, the growth of leaves and roots and fruits is weakened, the flow of nutrients is disturbed, and tolerance to bacterial and fungal diseases decreases (Gaafar *et al*., 2019).

Planting schemes are important factor which affect the quantitative as well as qualitative outcomes of sugar beet. Postponing the date of harvesting reduces variations between quantities of sugar attained from sugar beet genotypes cultivated in diverse planting times (Curcic *et al*., 2018). Mixture of plant density of 90,000 plant/ha and transplanting technique in a certain level of reduced irrigation with respect to entire irrigation level resulted in augmented yield of sugar beet (Khozaei *et al*., 2020). Research works are being continued rapidly to increase the production of sugar plants and their wide use in industry in the world (Dimcheva *et al*., 2021).

For this purpose, in order to improve sugar beet production, the effect of environmental factors, planting scheme and mineral fertilizer norms on the quality indicators of sugar beet was investigated.

MATERIALS AND METHODS

Before carrying the study of nutrient supply of irrigated gray-brown soils in the Ganja Regional Center for Agrarian Science and Innovation, where we conducted research; analysis of soil samples taken from 0-30 30-60 and 60-100 cm layers was performed. The analysis showed that the soils were highly deficient in available forms of nitrogen, phosphorus and potassium**.** The field experiments were laid out in the following scheme after the cotton predecessor with 2 factors (2x5):A factor-planting scheme: 1) 50x10 cm (200 thousand plants/ha); 2) 50x15 cm (133 thousand plants/ha); 3) 50x20 cm (100 thousand plants/ha).

Materials: Nitrogen-ammonium nitrate 34.7%, phosphorus-simple superphosphate 18.7%, and potassium-potassium sulfate 46% were used as mineral fertilizers in the experimental field. 70% of each of the Phosphorus and potassium were applied after plow in autumn, the remaining 30% of phosphorus, and potassium at the time of sowing. 50% of nitrogen was applied at sowing while remaining 50% of nitrogen during the leaf formation phase. Sowing was done on the 3rd decade of March every year. The report of sugar beet was carried out on all repetitions and variants, in phenological observations, leaf and root mass of beet by weight, root and fruit length, diameter, number of leaves,

Table 1. Agrochemical characteristics of the soils of the experimental area

depth	pH	humus, (%)	Nitrogen			phosphorus		Potassium	
			General nitrogen (%)	N/NH_3 (mg/kg)	N/NO_3 (mg/kg)	general (%)	(mg/kg)	(%)	(mg/kg)
0-30	7.8	2.16	0.16	18.7	10.3	0.14	16.5	2.41	265.5
30-60	8.2	1.18	0.09	12.5	6.5	0.09	8.0	1.85	165.0
60-100	8.4	0.83	0.06	6.8	2.8	0.07	4.8	1.53	108.5

length, etc. The risk of simulation was determined, laboratory systems were dried, hypnotized and the necessary analyzes were done. Agrotechnical measures were taken according to the accepted procedure.

In the collected soil samples: pH on the potentiometer, total humus according to Tyurin and Kononova (1963), absorbed ammonia according to D.P. Konev, nitrate nitrogen according to Grandval-Lyaju, total nitrogen, total phosphorus according to K.E. Ginzburg and G.M. Sheglova (1963), Phosphorus was determined by the method of B.P.Machin, total potassium by Smith, and exchangeable potassium by the method of P.B.Protasov in a flame photometer. In the example: in a thermostat at 1050 °C, plant total nitrogen, phosphorus and potassium according to K.E.Ginzburg, G.M.Sheglov and E.V.Wulfus, sugar (saccharose) in a saccharometer using an optical method, Nitrate nitrogen in the solution was determined by the method of A.G. Shestakov and B.P. Pleshkov.

In order to quantify the influence of weather conditions on crop growth, data on the influence of temperature and precipitation factors on sugar beet development during the study years were taken into account.

RESULTS

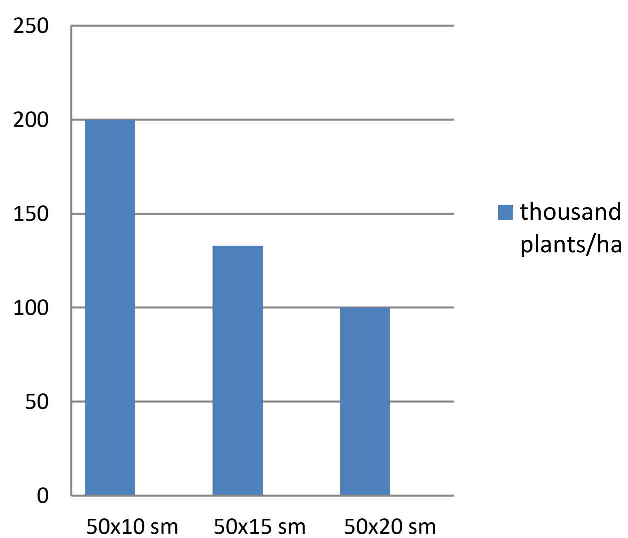

Figure 1. A factor-planting scheme

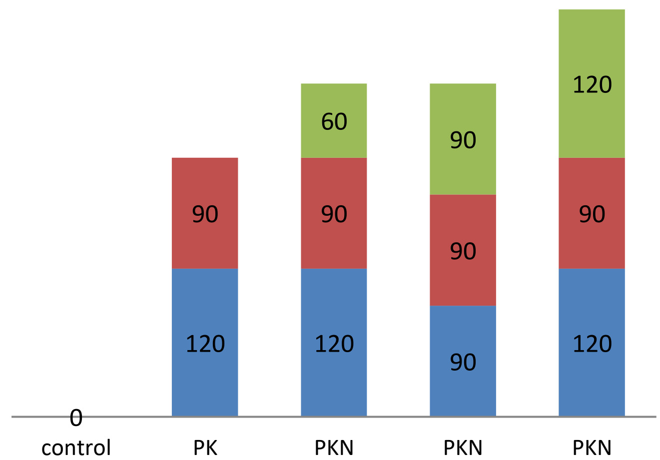

Figure 2. B factor-fertilizer rates

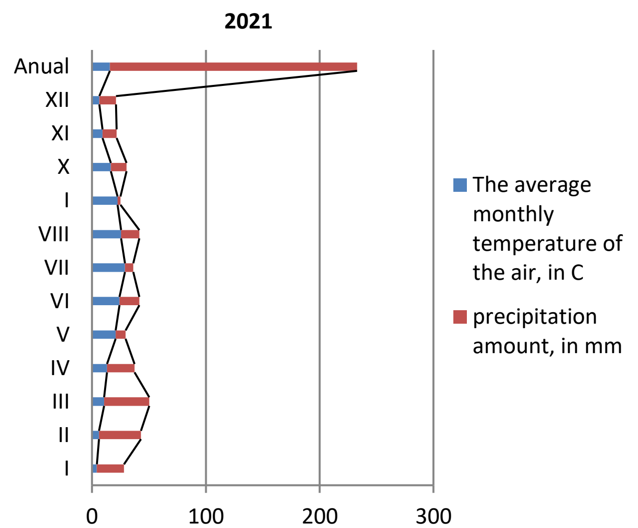

Figure 3. Average temperature and precipitation amount

A temperature of 18-24 °C is considered optimal for the formation of fruit-bearing shoots in the root head. During the summer sowing period, since the shoots are established in warm summer temperature conditions, they have higher viability than the shoots planted in spring (Alexandrov *et al*., 2000)

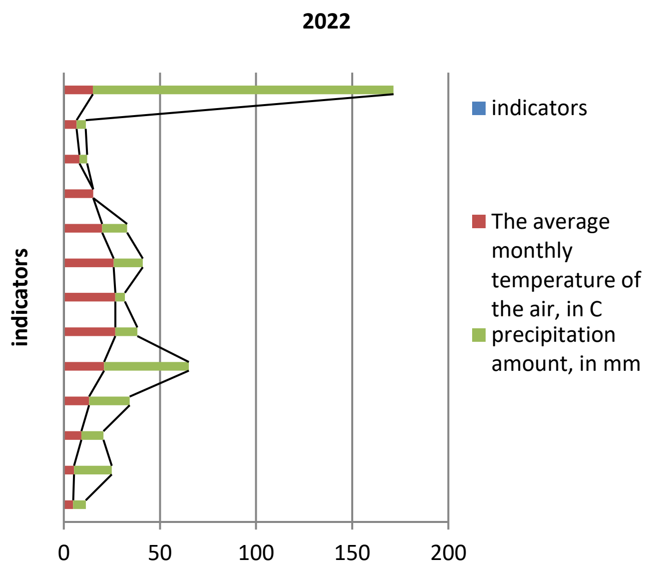

Figure 4. Average temperature and precipitation amount

The influence of the planting scheme and mineral fertilizers on the quality indicators of sugar beet (average from 2021-2022)

As can be seen from figure 4, in the 50 x 10 cm planting scheme, in the non-fertilizer (control) variant, dry matter is 20.6%, sugar is 15.1%, protein is 5.34%, fat is 0.57%, cellulose is 5, 66%, ash 4.42% and nitrate nitrogen 131.8 mg/kg in wet mass, respectively 21.5% in background ($P_{120}K_{90}$) variant; 15.4%; 5.78%; 0.62%; 5.71%; 4.47% and 135.5 mg/kg.

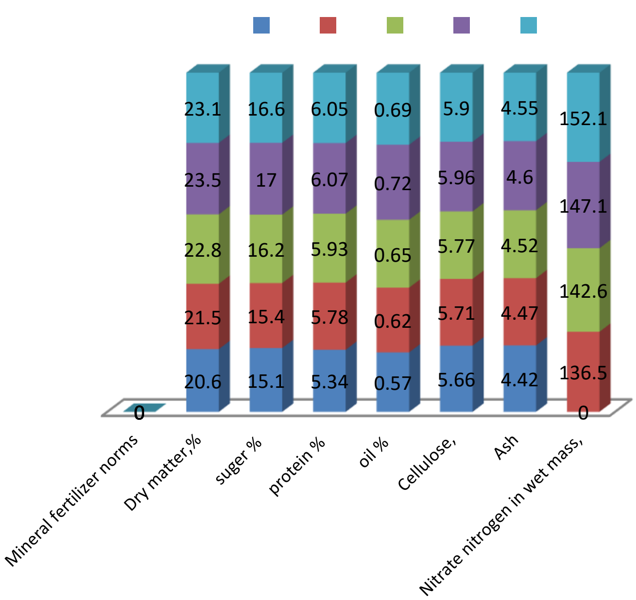

Figure 4. Planting scheme 50x10 cm

Compared to the control and background ($P_{120}K_{90}$) options, the quality indicators of sugar beet increased significantly, as in the case of root and fruit crops.

Thus, in the background +N_{60} variant, dry matter is 22.8%, sugar is 16.2%, protein is 5.93%, fat is 0.65%, cellulose is 5.77%, ash is 4.52%, and nitrate nitrogen is 142% in wet mass. 6 mg/kg, and the highest quality indicators were observed in the background+N_{90} variant, respectively 23.5%; 17.0%; 6.07%; 0.72%; 5.96%; 4.60% and 147.1 mg/kg.

With the background, the quality indicators of nitrogen fertilizer in the N_{120} norm did not affect the quality of sugar beet as much as compared to the (N_{90}) variant, and each of the studied indicators was lower except for nitrate nitrogen in the wet mass: dry matter 23.1%, sugar 16.6%, protein 6.05%, fat 0.69%, cellulose 5.90%, ash 4.55% and nitrate nitrogen was 152.1 mg/kg in wet weight.

Depending on the planting scheme (50 x 10 cm) and mineral fertilizer norms, 0.9-2.9% dry matter, sugar 0.3-1.9%, protein 0.44-0.73%, fat 0. 0.05-0.15%, cellulose 0.05-0.30%, ash 0.05-0.18% and nitrate nitrogen increased by 4.7-20.3 mg/kg in wet mass. The amount of nitrates in sugar beet roots was much less than the permissible limit (250 mg/kg in wet mass).

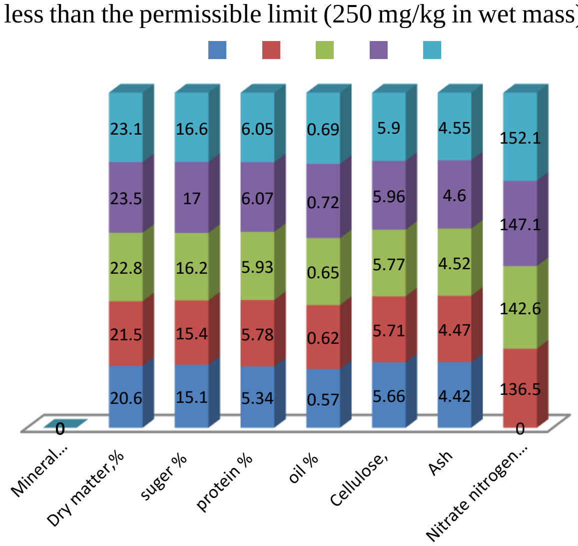

Figure 6. Planting scheme 50x15

According to Figure 6, in the 50x15 cm planting scheme without fertilizer (control), dry matter 21.2%, sugar 15.4%, protein 5.36%, fat 0.59%, cellulose 5.67%, ash 4.44% and nitrate nitrogen 144.4 mg/kg in wet mass, and 22.0% in background ($P_{120}K_{90}$) variant, respectively; 15.7%; 5.83%; 0.63%; 5.73%; 4.50% and 160.1 mg/kg.

The quality indicators of sugar beet increased significantly, as in the case of the 50x10 cm planting scheme, as compared to the control and background ($P_{120}K_{90}$) variants at increasing rates of nitrogen fertilizer along with the background. Thus, in the background+N_{60} variant, dry matter is 23.4%, sugar is 16.6%, protein is 5.92%, fat is 0.66%, cellulose is 5.81%, ash

is 4.58% and nitrate nitrogen is 167% in wet mass. 0 mg/kg, and the highest quality indicators were observed in the background+N_{90} variant, respectively 24.3%; 17.5%; 6.17%; 0.75%; 6.01%; 4.68% and 180.0 mg/kg. Along with the background, the quality indicators of N_{120} norm of nitrogen fertilizer did not affect the quality of sugar beet as much as compared to (N_{90}) option, and each of the studied indicators was lower except nitrate nitrogen in wet mass.

In the 50 x 15 cm planting scheme, depending on the mineral fertilizer norms, the quality indicators were higher in each of the studied variants than in the 50 x 10 cm planting scheme. 0.8-3.1% dry matter, sugar 0.3-2.1%, protein 0.47-0.81%, fat 0.04-0.16%, cellulose 0. 06-0.34%, ash by 0.06-0.24% and nitrate nitrogen increased by 15.7-42.6 mg/kg in wet mass. The amount of nitrates in sugar beet roots was much less than the permissible limit (250 mg/kg in wet mass).

As it is clear, in the 50 x 20 cm planting scheme without fertilizer (control) dry matter 21.4%, sugar 15.6%, protein 5.38%, fat 0.61%, cellulose 5.69%, ash 4, 46% and nitrate nitrogen 147.5 mg/kg in wet mass, 22.2% respectively in background ($P_{120}K_{90}$) variant; 15.9%; 5.85%; 0.65%; 5.77%; 4.53% and 163.8 mg/kg.

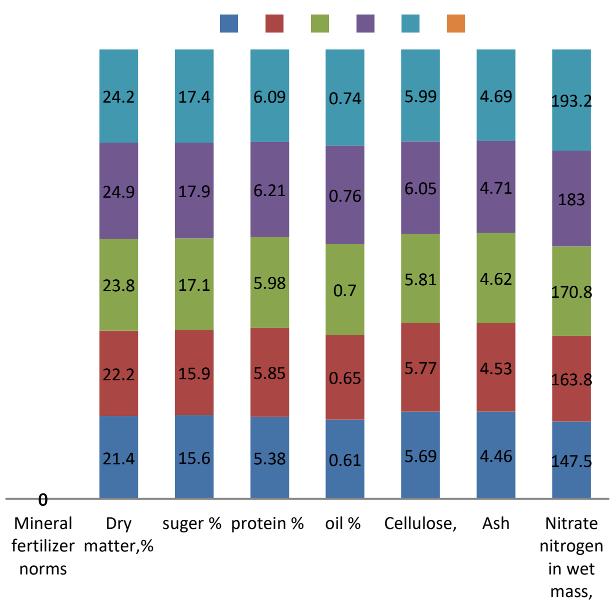

Figure 7. Planting scheme 50x20

The quality indicators of sugar beet, as well as root and fruit crops, increased significantly compared to the control and background ($P_{120}K_{90}$) variants in the increased rates of nitrogen fertilizer along with the background. Thus, in the background+N_{60} variant, dry matter is 23.8%, sugar is 17.1%, protein is 5.98%, fat is 0.70%, cellulose is 5.81%, ash is 4.62%, and nitrate nitrogen is 170% in wet mass. 8 mg/kg, and the highest quality indicators were observed in the background+N_{90} variant, respectively 24.9%; 17.9%; 6.21%; 0.76%; 6.05%; 4.71% and 183.0 mg/kg. Along with the background, the quality indicators of N_{120} norm of nitrogen fertilizer did not affect the quality of sugar beet as much as compared to (N_{90}) option, and each of the studied indicators was lower except nitrate nitrogen in wet mass.

In the 50 x 20 cm planting scheme, which has more food space, the quality indicators were higher in each of the studied options than in the 50x10 cm and 50x15 cm planting schemes, depending on the mineral fertilizer norms. 0.8-3.5% dry matter, 0.3-2.3% sugar, 0.47-0.83% protein, 0.04-0.15% fat, cellulose 0.08-0.36%, ash by 0.07-0.25% and nitrate nitrogen increased by 16.3-45.7 mg/kg in wet weight. The highest indicators were obtained in the background+N_{90} variant in all 3 planting schemes. The amount of nitrates in the root fruits of sugar beet was much less than the permissible limit (250 mg/kg in wet weight).

DISCUSSION

Our results were corroborated by Weeden (2000) noted reduced sugar yield at lower quantity of applied nitrogenous fertilizers which confirms our results. whom Barik (2003) who studied the part of nitrogen and potassium on qualitative yield of sugar beet and noted increased qualitative characteristics of sugar beet at certain concentration level of nitrogenous fertilizer as was recorded in our research work. Bzowska-Bakalarz and Banach (2009) studied the sugar beet production under varied fertigation approaches and recorded increased in quality parameters of sugar beet at augmented nitrogen levels as was recorded in current study. Mahmoud *et al*. (2014) whom found that qualitative response of sugar beet relies on quantity of fertilizer, applied. Similarly, Masri *et al*. (2015) recorded augmented qualitative characters in sugar beet at recommended dose rates of nitrogenous fertilizers. However, our results were not in line with Norton (2011) who observed that use of varied quantities of nitrogen caused non-significant alterations in percent contents of sugar in sugar beet and crop yield in terms of sugar in a variety of soils in USA. Kaffka and Grantz (2014) clarified that at decreased levels of nitrogen at a time prior to harvesting, growth and development of leaf got slow down as in compared to photosynthesis rate, and photosynthesis yields sucrose which amasses in under-ground part as reserve compared to instigation of more plant development.

Postponing the date of harvesting reduces variations between quantities of sugar attained from sugar beet genotypes cultivated in diverse planting times (Curcic *et al*., 2018). The similar trend was recorded in our research work. Khozaei *et al*. (2020) reported that blend of plant density of certain number of plants and transplanting technique in a certain level of reduced irrigation with respect to entire irrigation level resulted in augmented yield of sugar beet as was recorded in our research work. Dimcheva *et al*. (2021) noted that planting schemes comprising of optimal planting row to row and plant

to plant distances affected the sugar beet yield and qualitative characteristics as was observed in our research work. Our results were contrary to Norton (2011) observed that use of different sowing times and planning distances caused non-significant alterations in percent contents of sugar in sugar.

Conclusıon: Thus, in all three planting schemes, depending on the mineral fertilizer norms, the quality indicators were higher in each of the studied options than in the control (without fertilizer) option. The highest indicators were obtained in the background+N_{90} variant in all 3 planting schemes. The amount of nitrates in the root fruits of sugar beet was much lower than the permissible limit (250 mg/kg in wet mass). Among the planting schemes, the highest quality indicators were observed in the 50 x 20 cm planting scheme, which has more food area.

***Authors' contributions*:** Hasanali, A.A., Dilbar, A.H and Gunel A.F wrote manuscript; Dursun, A.L, Sima, Z.H. and cocieved the idea of research; Leyla, Q.N. proof read the manuscript.

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***Ethical statement*:** There is original research work and not yet published elsewhere and the authors declare that there is no conflict of interest

***Availability of data and material*:** Data will be available on realistic request.

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Code Availability: Not applicables

***Consent to participate*:** All authors are participating in this research study.

***Consent for publication*:** All authors are giving the consent to publish this research article in JGIAS

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